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Nutritional Value of Six Plantain Cultivars (*Musa* ssp) Grown in the Kindu Region, Maniema Province, DR Congo

Tambwe K. H[1], Solia E. S[2], Okungo L. A[3]
[1]Faculté des Sciences Agronomiques, Université de Kindu,
B.P. 50, Kindu, Democratic Republic of Congo
[2,3]Institut Facultaire des Sciences Agronomiques,
B.P. 1232, Yangambi, Democratic Republic of Congo

ABSTRACT

In order to determine the nutritional value of the six most popular plantain cultivars (*Musa spp)* collected in four areas of Maniema province, a study was carried out in which chemical analyses were carried out on their crude protein, crude ash, calcium, magnesium and iron compositions, as well as their moisture content. To do this, the prepared samples were taken to the laboratory of the Institut Facultaire des Sciences Agronomiques de Yangambi in Kisangani for assays of the elements selected, following the usual procedures. The results of these analyses showed that the six plantain cultivars tested differed numerically and statistically in nutrient content. It was noted that:

- Calcium ranged from 0.17 to 0.32%, with an average of 0.24%;
- Magnesium ranged from 0.42 to 0.82%, with an average of 0.56%;
- Iron showed a range of 0.05 to 0.10%, with the mean value equal to 0.07%;
- Crude protein ranged from 1.64 to 2.23%, with an average of 1.93%;
- Crude ash ranged from 1.3 to 3.2%, with an average of 2.1% for all the plantain samples studied.

All these results show that our cultivars are different from a nutritional point of view and that they are interesting from a nutritional composition point of view and statistically different.

Key words: nutritional value, cultivar, plantain, Kindu

INTRODUCTION

Bananas (dessert and plantain) are the world's main fresh fruit, and are the subject of major international trade. Its socio-economic and nutritional importance is considerable (Lassoudière, 1978).

Because of its importance (nutritional, dietary, economic, social, etc.), the plantain is the only fruit classified as a starchy consumer product worldwide (Adheka *et al.*, 2018).

The plantain banana (*Musa paradisiaca*) is the fruit of a perennial herbaceous plant belonging to the same species as the so-called "sweet" banana (*Musa sapientum*), the banana-fruit we know so well, of which it is a closely related hybrid. However, the two fruits are quite different: plantain is a cooking banana that is eaten more like a vegetable, whereas sweet banana is a fruit that is almost always eaten raw (Coulibaly, 2007).

Their compositions are also quite different, although both plantain and sweet bananas appear to be higher in carbohydrates and higher in energy than other fresh fruits.

Plantains have a very high carbohydrate content: over 28g per 100g. This is considerably higher than the carbohydrate content of sweet bananas (20.5g), and of course that of fresh fruit (which is generally around 9 to 12g). Even in a tuber like the potato, carbohydrates do not exceed 19 to 20 g per 100 g. The carbohydrate content of plantains is essentially made up of starch, hence the need to cook the food before eating it (Gnakri, 1993; Chandler, 1995).

Before cooking, 66% of plantain starch is resistant to pancreatic amylase (the body's enzyme capable of splitting the starch molecule into smaller particles). After cooking, the transformation of the starch by the amylase is complete. However, if you wait for the plantain to cool, 10% of the starch will resist the action of amylase. For better digestibility, it is therefore preferable to eat plantain quickly after cooking (Adeniji *et al.*, 2007; Brou Lazare Yao *et al.*, 2019).

In plantains, carbohydrates provide most of the total energy: 119 kilocalories or 497 kilojoules per 100g. As with most fresh vegetables, proteins are not very abundant (1%), nor are lipids or fats, which do not exceed 0.2%. After cooking, there is a very slight increase in carbohydrate content (30g per 100g), and a slight decrease in protein and fat content. But overall, the energy intake remains close to 120 calories (Coulibaly, 2007).

The plantain banana is therefore the fruit with the highest energy intake (well ahead of the sweet banana, with its 90 kilocalories), and also ahead of the potato (85 calories).

The fibre content of plantains is 5.8g per 100g (higher than in most fruits). It helps to give the fruit a fairly dense texture, and is involved in the metabolism of carbohydrates, making their assimilation even more gradual (Emma *et al.*, 2012).

The minerals in plantain are varied, and their levels are close to those in sweet bananas: potassium dominates (350 mg), followed by phosphorus (35 mg), magnesium (33 mg) and calcium (7 mg). A number of trace elements - iron, zinc and copper - were also measured in plantain bananas, but at slightly lower levels than in sweet bananas (Adeniji *et al.*, 2007).

The vitamin C content of raw plantains is relatively high: 20 mg per 100g. After cooking, however, values are much lower, at only 3 to 5 mg. Similar observations can be made for the B group vitamins, which are well represented: vitamins B1 and B2 fall from 0.05 mg to 0.01 mg after cooking, and vitamin B3 from 0.7 mg to 0.3 mg. Pro-vitamin A (or carotene) levels vary greatly depending on the variety: from 0.05 to 1.1 mg per 100 g, with bananas with a more pronounced flesh colour containing the most (Chandler, 1995).

In a study based on the morphological diversity of plantains in the province of Maniema (Kasongo, Kailo, Kibombo and Pangi territories), Democratic Republic of Congo, Tambwe (2019) listed 19 banana cultivars, including: 4 French-type plantains, 3 false horns, 2 true horns, 6 dessert-type bananas and 4 plantains.

Among the plantains inventoried, six cultivars are the most popular and cultivated in this banana-growing area: Kambelekete (Amakake), Mbudi I (Ikpolo rouge), Bonjilo "Bosakarakaka 1"; Kyankola (Magoma I); Mbudi II (Ikpolo rouge); Otangala (Egbe-O-Mabese I).

On the basis of these results, there is a need to deepen our knowledge of the six plantains through an agronomic and nutritional evaluation, in order to better classify and distinguish them. Determining the nutritional value would make it possible to determine the real food value of each of these plantain cultivars.

The aim of this study was to assess the nutritional value of the fruits of six plantain cultivars (*Musa paradisiaca* L.), collected in different areas of Manema province. These included ash, protein and mineral (calcium, magnesium and iron) content.

MATERIALS AND METHODS

Study Environment

The study was carried out in Maniema province: a total of six cultivars were evaluated in the Kailo territories and in the seven territories of Maniema, Democratic Republic of Congo. The seven territories in Maniema province are: Kailo, Kibombo, Kasongo, Pangi, Punia,

Lubutu, and Kabambare. Maniema province is located in the north-eastern region of the central Congolese basin. The map in Figure 1 shows Maniema with its different territories where the study was carried out.

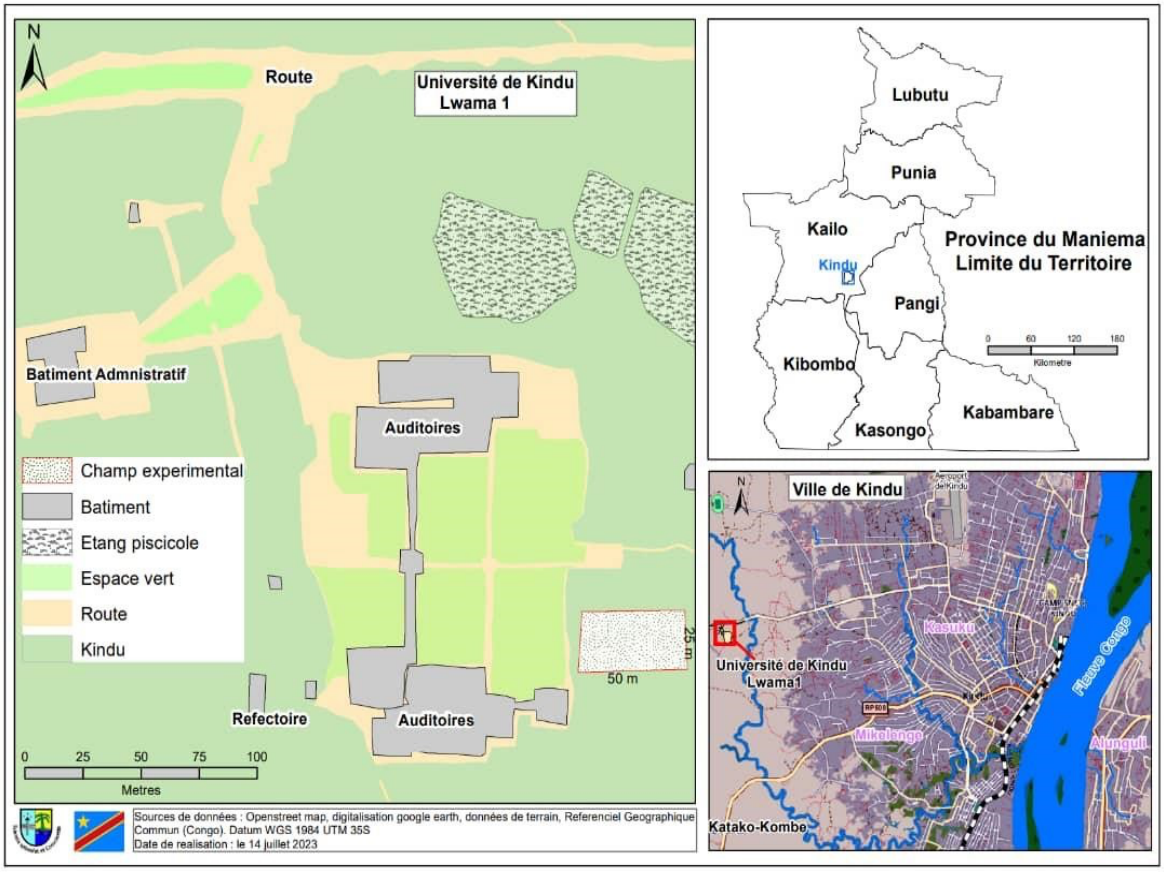

Figure 1: Plantain harvesting sites in Maniema province

The experiments took place on the premises of the concession of the University of Kindu, more precisely on the experimental site of the phytotech department located at Lwama 1, with geographical coordinates (S 02°56' 525°; E 025°53'118 and an altitude of 469 m) in the town of Kindu, Maniema province in the Democratic Republic of Congo.

The Kindu University concession has a relief that is characteristic of the central Congolese basin, with very little unevenness and a soil type of sandy-clay and sandy-clay, which allows all kinds of crops to be grown, whether market gardening, food crops or industrial crops. Located in the equatorial zone, our study area benefits from an equatorial climate: average monthly temperature varies between 22.5 and 29.3°C, with an annual average close to 25°C. As is the case throughout the central forest basin, annual rainfall varies between 1,500 and 2,000 mm, with an average of 1,750 mm (Vanden put, 1981).

Plant Material

The plant material used in this study consists of offshoots of the six most popular plantain cultivars grown and collected in the Kindu region, whose characteristics are shown in Figure 1 below. These are the cutivars: Kyankola (Magoma 1); Mbudi 1 (Ikpolo rouge); Mbudi 2 (Ikpolo rouge); Otangala (Egbemabese); Kambelekete (Amakake) and Bonjilo (Bosakarakaka 1). The characteristics and photographic illustrations are as follows (Figure 2):

Figure 2: Different plantain cultivars under study.

Methods

Preparation of samples for chemical analysis

The plantain fruit rejects (fingers) isolated by cultivar were peeled, cut into cossettes and sundried for a fortnight. Samples of the six cultivars were well packaged and taken to the IFA Yangambi laboratory for analysis.

The quantitative evaluation of the plantain fruits studied was carried out using three replicates per parameter. The nutritional parameters included crude ash, crude protein and three minerals (calcium, magnesium and iron).

Dosing of the main components

Determination of crude protein

The Kjeldahl method (Harris, 1982) is used to measure nitrogen in amine, amide, nitrate, nitrite and nucleic acid groups. It involves the following steps:

- Mineralization or digestion: the organic matter contained in the test sample is mineralized for 3 hours with 5 ml of hot 98% sulphuric acid, in the presence of 0.2 g of mixed catalyst, according to the following reaction:

$$(C,N,O,S,F)\ CO_2 + H_2O + SO_2 + PO_{27}^{4-} + CO + NH_4^+ + HSO_4^- \xrightarrow[\text{Catalyst}]{H_2SO_4}$$

- Alkalination and distillation: an excess of 40% caustic soda neutralises the 98% sulphuric acid used for mineralisation. The neutralised digestate is heated to boiling point (100°C) in the Kjeldahl distiller and 150 ml of distillate containing the ammonium ion (NH_4^+) is collected quantitatively in a container containing a 2% boric acid solution and the mixed indicator until the colour of the solution turns green. Ammonium borate is then formed according to the following reaction: $NH_4OH + H_3BO_3 \rightarrow NH H_{42} BO_3 + H O_2$
- Titration: ammonium borate is titrated with 0.01N sulphuric acid using the Tashiro indicator, which identifies the equivalence point by changing from green to red. Using the reaction $HR + NH H_{42} BO_3 \rightarrow H_3 BO_3 + NH_4 R$, we can determine the quantity of ammonium formed during titration. This quantity is used to determine the amount of nitrogen (%), which is used to determine the amount of crude protein using a correction factor. The procedure for this analysis is given in Appendix 1.

Dosing of crude ash

Raw ash is obtained after complete calcination of dry material at high temperature in a muffle furnace. The sample, of known weight and dry matter, is heated until the ash is obtained (Godon & Loisel, 1984). The procedure is described in Appendix 2.

Determination of mineral components

The mineral elements were determined by nitro-perchloric acid etching (Groegart, 1958), the procedure for which is given in Appendix 4.7. The solution obtained from this etching, known as the "mineralisate", was used to assay calcium, magnesium and iron, according to the procedure described below.

A. Calcium measurement

Calcium was determined using the EDTA complexometric method. This assay is based on the principle that the bisodium salt of EDTA forms complexes with bivalent and trivalent metals. It forms a very stable complex with the Ca^{2+} ion in an alkaline medium (pH 13). Titration is carried out in the presence of a calcon indicator, which turns the solution from red-violet to blue at the end of the titration. As most of these actions are also complexed under the same conditions, they are removed from the reaction medium using triethanolamine (Charlot, 1966).

B. Magnesium dosage

The principle is the same as that of calcium determination, but here magnesium is complexed in the form of $Mg(OH)_2$ at pH 10 maintained by ammonia buffer. It is determined by complexing the sum of Ca^{2+} and Mg^{2+} with EDTA using the black eriochrome indicator T, which turns from red-violet to clear or faded blue at the end of the titration. Its concentration is deduced by subtracting the concentration of Ca^{2+} determined previously (Charlot, 1966).

C. Iron dosage

The equation $6Fe^{2+} + Cr\ O_{27}^{2-} + 14H^{+} \rightarrow 6Fe^{3+} + 2Cr^{3+} + 7H_2\ O$ is the basis of iron titration. The titration term is marked by diphenylamine, an indicator which produces a violet-blue coloration in the solution at the equivalence point (Dessart *et al.*, 1973).

PRESENTATION OF RESULTS

The concentrations of various components measured in the fruits of the six plantain cultivars under study are presented as follows

Protein and Ash Content

The results relating to the mean values of these two parameters are shown in Table 1. The raw results can be found in appendix

Table 1: Crude protein and ash content of six plantain cultivars

Cultivars	Crude protein		Crude ash	
	Average	CV (%)	Average	CV (%)
C1	$1,64\pm0,11^{a}$	6,71	$2;0\pm0^{ab}$	0,00
C2	$1,96\pm0,11^{bc}$	5,61	$2,5\pm0,87^{ab}$	34,64
C3	$2,12\pm0,06^{bd}$	2,59	$2,3\pm0,58^{ab}$	24,74
C4	$1,80\pm0,05^{ac}$	2,80	$3,2\pm0,29^{a}$	9,12
C5	$2,23\pm0,06^{d}$	2,47	$1,3\pm0,82^{b}$	62,96
C6	$1,85\pm0,11^{ac}$	5,67	$1,3\pm0,58^{b}$	43,30
ANOVA	**F = 19.54; p-value = 0,0000217 *****		**F = 4.296 p-value = 0.0179 ***	

Legend: C1: Kyankola; C2: Mbudi 1; C3: C4: Mbudi 2; C5: Otangala; and C6: Mbonjilo

Table 1 shows that the protein and crude ash contents of these six plantain cultivars vary from one cultivar to another but are grouped around the averages. Statistical analysis showed that the differences between the cultivars were highly significant in terms of protein content, but significant in terms of crude ash content.

Protein content ranged from 1.64±0.11 to 2.23±0.06. There are very highly significant differences between cultivars.

The same trend was observed for the crude ash content, i.e. the cultivars studied differed statistically. Mean values ranged from 1.3±0.82 to 3.17±0.2 9.

Mineral Element Content

Data on the average calcium, magnesium and iron content of the six cultivars under study are presented in Table 2.

Table 2: Mean values of Ca, Mg and Fe content in the banana plants studied

Cultivars	Magnesium		Calcium		Iron	
	Average(mg)	CV (%)	Average	CV (%)	Average	CV (%)
C1	0,55±0,05^{ab}	9,09	0,17±0,03^{a}	14,52	0,10±0,0^{a}	0,00
C2	0,62±0,03^{b}	4,04	0,30±0,0^{b}	0,00	0,07±0,03^{ab}	34,32
C3	0,47±0,08^{ac}	15,86	0,22±0,03^{ac}	11,27	0,05±0,0^{b}	0,00
C4	0,82±0,03^{d}	3,06	0,32±0,03^{b}	8,27	0,05±0,0^{b}	0,00
C5	0,42±0,03^{c}	5,94	0,25±0,0^{bc}	0,00	0,07±0,03^{ab}	34,32
C6	0,52±0,03^{bc}	4,81	0,20±0,05^{ac}	25,00	0,10±0,0^{a}	0,00
ANOVA	**F = 33.9; p-value = 0.00000112 *****		**F = 13.14; p-value = 0.000161 *****		**F = 7.116; p-value = 0.00262 ****	

Legend: C1: Kyankola; C2: Mbudi 1; C3: C4: Mbudi 2; C5: Otangala; and C6: Mbonjilo

Analysis of Table 2 shows that mineral levels vary from one cultivar to another, and all the data are generally homogeneous except for iron in cultivars C2 and C5. The cultivars also differ greatly in their calcium and magnesium content, but greatly in iron. Cultivar C4 is richer in Ca and Mg than all the others, while cultivars C1 and C6 are richer in Iron.

DISCUSSION OF THE RESULTS

Bananas are known as a nutritious food because they contain a variety of nutrients including protein, fat, carbohydrates, fibre, vitamins and minerals. Doymaz (2010) indicates that they contribute to health by providing various minerals such as calcium, magnesium, potassium and various vitamins. It has an energy content of around 100 kcal/100g, and is easily digested when ripe. This makes it a very suitable fruit for babies from the age of 3 months, and an important addition to the basic diet.

The results relating to crude protein and crude ash content obtained during this study showed that the six cultivars differ in terms of chemical composition. The crude protein content varied from 1.64±0.11 to 2.23±0.06%; the crude ash content from 1.3±0.82 to 3.17±0.2 9.%. This protein content is lower than that found by some researchers, but slightly higher than the general average for plantain, estimated at 1% (Coulibaly, 2007). Indeed, Amidou (2007), found higher protein contents than those obtained in this work in the cultivars Libanga likale (5.3%), Lingu (4.3%) and Litete (3.82%). Emma *et al.* (2012), in a study focused on the biochemical characterisation and sensory evaluation of Agnrin vari "t plantain fruits from the Ivory Coast, found crude protein contents in the range of 3.27 to 5.01%, while the ash content was in the range of 1.47 to 2.18%? lower than that obtained in this study. These differences are due to

the cultivars analysed, as each has its own genetic characteristics, and to the culture media used. In addition, the analysis techniques used in the different laboratories had an influence on the results obtained in each study.

Compared with the data reported by Dhed'a *et al.* (2011), the plantains presented have higher crude protein contents than those analysed in this research. These cultivars include Magoma 1 (6.71%), Bosakarakaka 1 (5.67%), Ikpolo rouge (5.61%); Tala lola (2.59%); EgbeO-Mabese I (2.80%); Bosakarakaka 1 (5.67%) and Amakake (2.47%). The difference is attributable to the cultivars analysed. In fact, as the plantain cultivars analysed in these different studies are different, it is obvious that the results are also different. There were also differences in the analysis procedures used by the various researchers.

In a study of the biochemical, functional and sensory characteristics of different flour formulations based on plantain (*Musa paradisiaca*) and manioc (*Manihot esculenta)* intended for the preparation of foutou, Brou Lazare Yao *et al.* (2019), obtained higher values of 3.06 ± 0.62 for green banana and 3.93 ± 0.62 for ripe banana in the proportion 60 and 40% banana and manioc. These results also show that the crude protein content of plantain depends on the cultivar and values can be low or slightly high.

As for the mineral elements, we found that the average contents are respectively from 0.17 to 0.32% with an average of 0.24%; for calcium; from 0.42 to 0.82% with an average of 0.56%. for magnesium and from 0.05 to 0.10% with an average value of 0.07 % for iron. These values have slightly higher than those obtained by Emma *et al.* (2012) in a study on the biochemical characterization and sensory evaluation of plantain fruits vari "t "Agnrin from Cote d'Ivoire. The differences are explained in the same way as for crude ash and protein content. In fact, the differences between cultivars and the analysis procedures would be the causes of the differences observed.

CONCLUSION

This study assessed the notional value of the six most popular and cultivated plantain cultivars collected from four areas in Maniema province, DR Congo.

To do this, the prepared samples were taken to the laboratory for chemical analysis (assays) of certain nutrients, including crude protein, crude ash, calcium, magnesium and iron.

The results of these analyses showed that the six plantain cultivars tested differed numerically and statistically in nutrient content. These analyses gave the following results:

- The overall calcium content varied from 0.17 to 0.32%, with an average of 0.24%;
- The percentage of magnesium ranged from 0.42 to 0.82%, with an average of 0.56%.
- The iron content varied from 0.05 to 0.10% with an average value of 0.07%;
- Crude protein and crude ash ranged respectively from 1.64 to 2.23% with an average of 1.93% and from 1.3 to 3.2% with an average of 2.1%.

All these results show that our cultivars are different from a nutritional point of view and that the C4 cultivar is more interesting.

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